New mineralisation windows in East Riverina: Results from the five-year mapping project
Contents

• Introduction

• Early Silurian epithermal–porphyry systems

• Early Devonian intrusion-related systems
  • Intrusion-related tin
  • Intrusion-related gold
  • Porphyry–epithermal gold

• Early to Middle Devonian structurally controlled low sulfidation gold mineralisation

• Conclusions
East Riverina mapping project

5-year project (mapping 2014 to 2018)
• finalisation of line work, data and reports in 2019.

Update geological knowledge
• previous maps mostly from 1960–70s at 1:250 000
• increasing land use pressures.

Multi-disciplinary approach
• ‘Boots on the ground’ mapping with specialist input.

Applied research projects
• e.g. Uni of Newcastle, Lachlan Orogen ARC.

Local engagement
• professionals and community.
Surface geology from NSW Seamless Geology over 1vd TMI

Source: Glen 2013
New data

>7250 new observations & measurements (FieldObs)
  • available in MinView
  • includes photos, sample and analytical information.

~200 new age determinations
  • >100 new isotopic:
    o SHRIMP (Geoscience Australia)
    o Ar–Ar (UoM, ANU), LA ICPMS (UoN, JCU, MU)
  • >90 new palaeontological:
    o conodonts, graptolites, fish and invertebrates.
New linework

Into Seamless Geology

Four provinces:

- Lachlan Orogen (LAO)
- Western Devonian Basins (WDB)
- Cenozoic Igneous Province (CIP)
- Cenozoic Sedimentary Province (CSP).
New ideas

Available via East Riverina webpage:

- 18 x GS reports – field work
- 2 x GS reports – palaeontology
- 6 x GS reports – SHRIMP U–Pb (co-branded as Geoscience Aust. records)
- 2 x GS reports – LA ICPMS U–Pb
- 1 x GS report – mineral systems
- 1 x GS report – hydrogeochemistry (CSIRO)
- GS report, QN, paper – remote sensing (RMIT)
- 2 x Masters thesis, 2 x Honours thesis (UoN)
- Various conference posters, abstracts, talks
- Plus more reports coming soon
  - e.g. mineral systems and synthesis reports.
Today’s focus

Mineral systems associated with Siluro-Devonian magmatism and deformation
Early Silurian epithermal–porphyry systems
Epithermal–porphyry systems

Magnetic linears along Gilmore Fault Zone associated with intermediate to mafic rocks

Previously interpreted as:

• Continuation of the Junee–Narromine Volcanic Belt of the Macquarie Igneous Province (Benambran Cycle);
• Associated with opening of the Tumut Trough (Tabberabberan Cycle);
• Of uncertain or mixed origin.
Epithermal–porphyry systems

Gidginbung–Temora belt

- Part of Junee–Narromine Volcanic Belt (MIP)
- Late Ordovician – Early Silurian
- Epithermal mineralisation
  - e.g. Gidginbung
- Porphyry mineralisation
  - e.g. Donnington

Source: Sandfire Resources, Cronin et al. (2017)
Epithermal–porphyry systems

Junawarra Volcanics

• Associated with high sulfidation epithermal and carbonate base-metal mineralisation at Dobroyde (Diemar and Hughes 2018).

• First U–Pb geochronology
  o $431.1 \pm 1.8$ Ma for a porphyritic andesite at Dobroyde
  o $432$ Ma (prelim.) for an autoclastic andesitic breccia to south.

• Tholeiitic affinity, with trace element characteristics indicative of a non-subduction setting (Eastlake 2018).

• New mapping of ‘jasper’ overlying mafic rocks
  o evidence of hydrothermal fluids associated with eruption.

Epithermal–porphyry systems

Cooba monzonite

• High-K, subduction-related monzonite identified
  o 439 Ma (prelim. age, Bodorkos et al. in prep.)
• Similar age and geochemical affinity to mineralised intrusions at Cadia and Goonumbla
• Associated with historical copper workings.

Epithermal–porphyry systems

Implications:

• Junawarra Volcanics younger (~432 Ma) with tholeiitic geochemical affinity
  o Represent opening of Tumut Trough
  o Contemporaneous with S-type granites.
  o Associated with Dobroyde and hydrothermal activity

• Monzonite at Cooba has similar age and geochemistry to Cadia and Goonumbla
  o Extends ~439 Ma Phase 4 Macquarie Igneous Province to south.

Source: Eastlake (2017) after Crawford et al. (2007)
Early Devonian intrusion-related systems
Intrusion-related tin

The southern part of the ‘Wagga Tin Belt’.


- Unmined total resource (tailings, waste, hard rock) of 66,500 t of contained tin.

Also tin–tungsten at Burrandana.

Source: Australian Tin Resources, Thomson Resources
Intrusion-related tin

Ardlethan area

- Breccia pipes (e.g. Ardlethan mine)
- Tin-bearing greisen zones and veins (e.g. Bygoo).

Source: Thomson Resources after Blevin (1998)
Intrusion-related tin

What age is mineralisation?

- Previously assumed to relate to the S-type, ~430 Ma Koetong Supersuite
- Though Ardlethan thought to be younger (Blevin 2010)
- New mapping, petrography and geochronology have differentiated magmatic history.
- Tin mineralisation is younger
  - ~414 Ma.

Source: Bull & Blevin (2016)
Implications:

- Tin prospectivity study completed pre-East Riverina mapping project
  - ~430 Ma Koetong Supersuite was a key theme in weights of evidence approach
  - Now know that tin mineralisation is associated with Early Devonian magmatism (~414 Ma)

- Upcoming exploration model and mineral potential mapping for intrusion-related tin in zone 55 west
  - Will incorporate new data and ideas

- Mapping has constrained exploration search space.

Source: Guj & Mamuse (2013)
Intrusion-related gold

Hobbs Pipe (near Mount Adrah) focus

- 20.1 Mt @ 1.12 g/t Au for 727,727 oz Au.

Several quartz monzonite to monzodiorite intrusions identified in Ordovician Abercrombie Formation country rock

- Hobbs Pipe dated at 414.7 ± 2.6 Ma, SHRIMP U–Pb zircon (Waltenberg et al. 2015).

Gold mineralisation:

- Disseminated within Hobbs Pipe intrusive body
- Quartz reefs in Abercrombie Formation.

Source: White (2013), 0.50 g/t cut off

Surface geology (NSW Seamless Geology) over 1VD TMI.
Intrusion-related gold

New GS report by Wang et al. (in prep.)
  • Integration of HyLogger™ data, petrography, sulfur isotopes
  • Confirms intrusion-related gold genesis.

Sericite‒calcite‒leucoxene‒pyrite‒arsenopyrite alteration:
  • Associated with gold mineralisation in the intrusion
  • Within margins of high-grade gold-bearing reefs in host rocks
  • Overprints regional foliation.

Sulfur isotopes indicated magmatic-dominated source.

Source: Waltenberg et al. 2015, Wang et al. (in prep.)
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Intrusion-related gold

Implications:

• Intrusion driver for mineralisation
  o Intrusion
  o Country rock.

• Hobbs Pipe is exposed mineralised ~415 Ma intrusion in hanging wall of the Gilmore Fault Zone.

• Other blind intrusions in same structural setting?
  o Leucoxene as vector?

Source: Geoscience Australia, Spampinato (2018) – GS2018/0576,
Porphyry–epithermal gold

Focus on the Traist prospect in Howlong area
Porphyry–epithermal gold

Porphyritic intrusions along a splay of the Kancoona Fault.

- Gold mineralisation hosted by porphyritic intrusions and Ordovician Abercrombie Formation country rock.
- Dextral strike-slip movement interpreted from aeromagnetic imagery
- Consistent with kinematic history of Kancoona–Kiewa fault zone in Victoria.

New mapping, petrography and geochronology for Jindera Granite.

- Series of metaluminous, highly fractionated, I-type lobes younging to the south (Bull 2017)
- ~407 to ~403 Ma (Bodorkos et al. 2015, in prep.).
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Porphyry–epithermal gold

New GS report by Forster et al. (in prep.):

• Integration of HyLogger™ data, petrography, geochronology, sulfur and lead isotopes

• New Re–Os age of molybdenite of 404.4 ± 1.5 Ma at Traist – within error of the Jindera Granite

• S isotopes – magmatic-dominated sulfur source

• Pb isotopes – typical Lachlan Orogen Early Devonian granite signature

• Concludes that mineralisation at Traist is epithermal carbonate base-metal–gold mineralisation.

Source: Forster et al. (in prep.)
Porphyry–epithermal gold

Implications:

• Newly recognised ~405 Ma magmatic event with gold mineralisation

• Intrusions along splays of major fault system
  o Kancoona (Boothagandra)–Kiewa FS

• Poor exposure
  o Traist porphyry is only intrusion exposed.
Early to Middle Devonian structurally controlled low sulfidation gold mineralisation
Structurally controlled gold

Gold mineralisation along Gilmore Fault Zone

- Plus parallel faults and related faults.

New GS report (Stuart et al. in prep.) reviewed individual goldfields in a regional context

- >500 occurrences with 32.2 t (1.14 Moz) Au
- Gold is hosted by range of Ord‒Sil‒Dev lithologies
- Timing Early (Bindian) to Middle Devonian (Tabberabberan) – though little direct dating.

Gold occurrences (MetIndEx) with surface geology (NSW Seamless Geology) over 1VD TMI.
Structurally controlled gold

Three main settings …

1. Narrow vein arrays within relatively competent rock types adjacent to second or third order splays of the GFZ and parallel structures.
   - e.g. Adelong, West Wyalong.


Gold occurrences (MetIndEx) with LAO geology (NSW Seamless Geology) over 1VD TMI.
Structurally controlled gold

Three main settings …

2. Along contacts between granites and metasedimentary country rock, or in pressure shadows near granites, where fluids have been focussed along contacts or around competent bodies.
   - e.g. Grong Grong.
Structurally controlled gold

Three main settings …

3. Gold associated with folding adjacent to the GFZ.
   • e.g. Barmedman.
Implications:

- Structural setting key
  - Crustal scale and associated faults
    - geometry and kinematics
  - Lithology of host not as critical as inflections, contrasts, contacts etc.
- Multiple Devonian gold-forming events
- Importance of quality mapping to identify key criteria for mineral potential mapping.

Source: Orogenic gold mineral potential mapping (Kenex Pty Ltd), after Knox-Robinson and Wyborn (1997)
Conclusions
Conclusions

New data, line work and ideas from mapping project

Increased understanding of:
- Siluro-Devonian magmatic history
- Structural framework, kinematics and history.

Implications for mineral systems and exploration
The work of many!

Geological Survey of NSW:
- Phil Blevin, Michael Bruce, Kate Bull, Lorraine Campbell, Astrid Carlton, Daniel Cronin, Liann Deyssing, Mark Eastlake, David Forster, John Greenfield, Kyle Hughes, Karen Montgomery, Bob Musgrave, Ian Percival, Glen Phillips, Mel Ricketts, Lawrie Sherwin, Cait Stuart, Steven Trigg, Yamei Wang, Brad Williams, Yong-Yi Zhen.

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Previous workers – exploration, government, academics